

NASA Range Safety Program 2006 Annual Report

SPECIAL INTEREST ITEMS DISTANT FOCUSING OVERPRESSURE (DFO)

Distant focusing is defined as *an atmospheric phenomenon that can produce greatly enhanced overpressure due to sonic velocity gradients with respect to altitude*. These enhanced overpressures can break windows in distant communities, which may result in personal injury. Distant focusing overpressure, sometimes referred to as *far field blast overpressure*, is of concern in the event of a large explosion on or around the launch pad and occurs only under certain meteorological conditions.

A variety of launch accident scenarios may lead to an on- or near-pad explosion. Examples include an intact vehicle impact with the ground or tower, a partial vehicle break-up that produces ground impacts of liquid propellant tanks or solid rocket motor segments, or vehicle tip-over at the pad due to one or more of the solid rocket motors not firing properly. Mitigation from these near field overpressure hazards includes establishing a quantity-distance criteria or evacuating personnel from areas of high risk. Data from near field overpressure plus atmospheric data is used to determine distant focusing overpressure.

Near field overpressure waves travel supersonically through the atmosphere and are not significantly affected by differing meteorological conditions as they expand radially from the explosion's source (picture at right). As the wave energy dissipates to levels less than a few pounds per square inch, the wave's propagation pattern changes to more closely resemble a standard acoustic wave. Therefore, the prediction of blast wave effects at intermediate to long distances can be based on the same basic principles that describe the propagation of acoustic waves, namely Snell's law.

Determining the Potential for Focusing

To determine the potential for focusing, atmospheric conditions must be monitored and evaluated. Two atmospheric parameters are paramount in determining acoustic wave propagation: wind speed gradients and temperature gradients. Relative humidity and pressure are also involved to a lesser extent. From these parameters, a sonic velocity profile (with altitude) is determined for each azimuth around the launch pad to determine if conditions are favorable for overpressure focusing. Sonic velocity is *the calculated speed of sound plus a directional wind speed component*. In basic terms, as the sonic velocity decreases with altitude, wave fronts are refracted upward or away from the ground. As the sonic velocity increases with altitude, wave fronts are refracted downward or toward the ground.

Understanding the attenuation conditions and their effect on overpressure strengths at population receptors, the risk of breaking windows and causing

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serious injuries can be calculated. Because distant focusing overpressure is not a hazard that can normally be contained within the base boundaries, a risk-based approach for evaluation has been accepted by the range community. Flight safety analysis is used to establish launch commit criteria, usually expressed in terms of casualty expectation (E_c), that protect people from any hazard associated with far field blast window breakage effects due to potential explosions during launch vehicle flight.

BLASTDFO Computer Model

A physics-based computer model, commonly referred to as *BLASTDFO*, is used to assess the risk associated with far field blast overpressure. The model was developed by ACTA Inc. and includes modules and databases to calculate and assess potential explosive yields, acoustic ray traces, receptor overpressures, glass breakage, base and community population and window information, human vulnerability, and individual and collective casualty expectation.

Just before launch, the distant focus overpressure flight analyst evaluates current weather conditions and identifies any areas that may be subject to enhanced or focused overpressure. Ray tracing plots, like the one shown to the left, are analyzed to determine if enhanced or focusing conditions are present. These regions represent the areas where glass breakage is most likely to occur. Average overpressures, window breakage, and casualty expectations are then calculated. If either the individual or collective casualty risk exceeds launch commit criteria and cannot be mitigated to acceptable levels, the analyst will recommend a launch hold.

Two products of BLASTDFO are shown below. On the left is an example of isopleths of probability of focus. On the right is an example of peak overpressure. Distant focus overpressure hazards occur almost instantaneously with the anomaly, so these products are forwarded to emergency planning managers to aid in any required emergency response preparation.

Fortunately, on-base distant focus overpressure risk is fairly easy to mitigate. When facilities at higher risk are identified, personnel are requested to move away from windows or simply go outside (away from windows) to watch the launch. Not a bad compromise!